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MOTION PLANNING FOR RELOCATABLE ROBOTS PERFORMING ON-ORBIT LOCOMOTION AND MANIPULATION TASKS

Abstract

In-space assembly is a key technology for the future development of large infrastructures in space, from space stations and telescopes, to solar-powered plants or planetary bases. Such structures are much larger than cargo areas in current launchers, therefore they must be sent in separate pieces that are assembled in-situ, typically using robotic manipulators. Different robotic manipulators are in service in space now, e.g. CANADARM2, or ERA. These manipulators can typically execute simple pick and place and manipulation tasks, and have limited relocation capabilities.

Recent projects within the European Union have explored new concepts for robotic loco-manipulation. Within the project MOSAR, a Walking Manipulator (WM) with 7 degrees of freedom (DoF) was developed to perform on-orbit assembly and reconfiguration of modular satellites using replaceable modules. The satellite is endowed with Standard Interconnects that provide mechanical, power and electric connectivity to the modules and to the robot. The WM is capable then of relocating and performing manipulation tasks; a ground demonstrator was developed to show the capabilities under lab conditions. However, a single arm has strong limitations in reachability and mobility. Within the project MIRROR, funded by ESA, a Multi-Arm Robot (MAR) is developed to perform assembly tasks for a large telescope. The robot consists of a torso and two 7-DoF arms attached to it. A ground demonstrator for this robot is currently under development.

The efficient exploitation of the loco-manipulation abilities for such robots requires suitable planning tools. This paper presents an approach to plan activities of locomotion, grasping and manipulation of objects with relocatable space manipulators such as the WM and MAR. The approach is based on a hybrid planner that combines a high-level layer, representing the discrete transitions from one contact state to another, and a low-level layer considering the joint trajectories to move from a contact state to the next one. The low-level layer is based on an RRT motion planner, which respects joint limits in position and torque, to provide collision-free trajectories. The high-level layer utilizes a graph representation of the locomotion problem to provide a trajectory that e.g. minimizes the overall displacement of the robot, while guaranteeing the execution of the intended task, either locomotion, manipulation or loco-manipulation.

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